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MECHANICAL AIDS TO THE STUDY AND RECORDING OF LANGUAGE[1]

By P. E. GODDARD

Language is essentially two-fold, consisting of spoken sounds and mental concepts. Only in comparatively recent times and among certain peoples have written symbols been employed to represent the sounds. There are only a few among those having written characters who are able to connect them directly with the mental concepts. The vast majority must go from the written symbol first to the sound and then to the mental concept. In ordinary practice then, writing is simply a device for bringing to one's own mind, or to the mind of another, sounds which are well known. Unless the sounds are known, or can be made known by other means, the written characters fail both in conveying them to those who are interested in their study, and in preserving them after the language of which they are a part has ceased being spoken. Nowhere has the inadequacy of alphabets, however ingenious, made itself more felt than in the field of American languages.

The only proper method of learning a language is to go among those who speak it, to hear it constantly and practise speaking it. For a child there is little difficulty in this, but a person who has reached his majority finds it practically impossible to acquire a foreign language so as to be able to speak it without an accent. For the practical purpose of making one's self understood this accent matters little, but for the scientific study of a language such imperfect pronunciation is far from satisfactory. The difficulty seems to lie almost entirely in the lack of ability of the person to hear correctly the sounds uttered. He does not realize that his own speech of the acquired language is imperfect, or at least he does not know in what particulars it is faulty, and therefore is unable to perfect it. To remedy this fault the ear must be aided by some means.

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[1] Read at the meeting of the American Anthropological Association, Berkeley, California, August 31.

The lip movements may be directly observed by the eye. Where a comparison between the sounds made in part by the lips, in the same or in a different language, is desired, the camera may be employed. The subject should be placed in strong sunlight and a very rapid lens and shutter used. The photographs so taken may be arranged, measured, and compared. By this method it may be readily shown what vowels in the language are rounded, the relative degree of lip opening for each vowel, and the amount of lip activity characterizing the language as a whole.

To a certain extent tongue movements may also be directly observed, but more difficulty is experienced with them than with the lip sounds. To determine and fix the movements of the tongue certain mechanical devices may be employed. The simplest of these is the artificial palate.[1] This should be made as thin as possible and adjusted so as to fit the roof of the mouth perfectly. The work can be done by any good dentist. There is difficulty in extending the artificial palate beyond the joining of the soft and hard palates because the movement of the soft palate is likely to dislodge it and its pressure upon the soft palate often produces gagging. The palate, which must be perfectly dry, is dusted with powdered chalk and put in place. Single syllables should be uttered, care being taken that a complication of impressions is not brought about. Where the naturally moist tongue touches the surface of the palate the chalk is removed and the black surface is exposed. The palate should be quickly and carefully removed from the mouth and photographed. This method fixes the exact position occupied by the tongue in making a certain sound, provided the contact is upon the hard palate or the teeth. By this means it is shown that a Hupa, who speaks his own language perfectly and English fairly well, makes the contact for *d* in Hupa considerably farther forward than he does for English *d* (pl. XXXVI, figs. 5 and 6).

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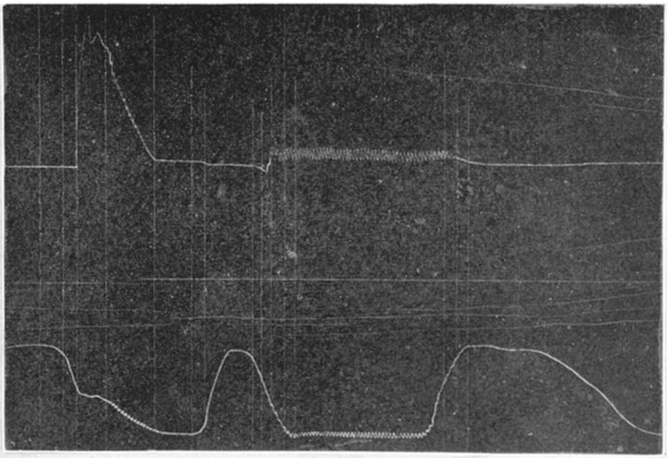
[1] Dr Norman Kingsley seems first to have employed this method for the correction of oral deformities. It has been frequently employed for linguistic purposes in Europe. Kingsley, *On Oral Deformities*, London, 1880. Scripture, *Elements of Experimental Phonetics*, New York, 1902, p. 298.



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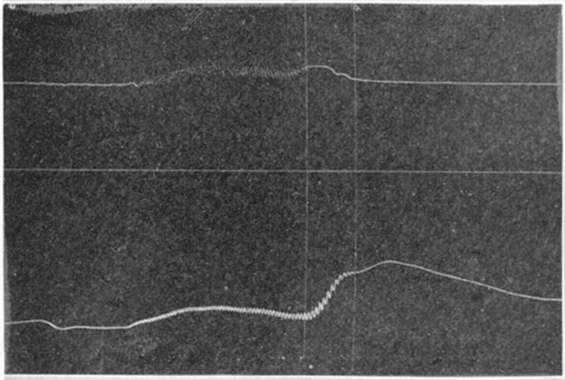

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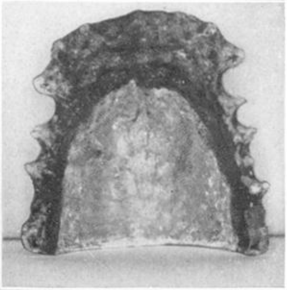

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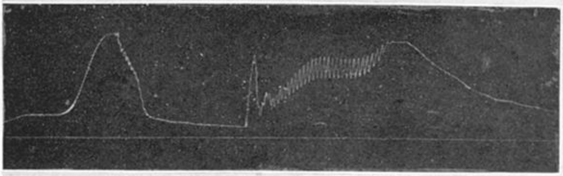

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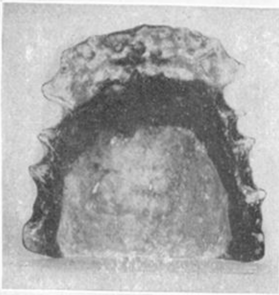

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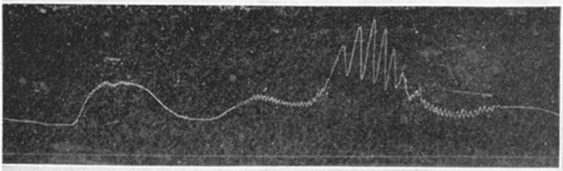

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1. Tracing of *tanan* (mouth and tip of tongue). 2. Tracing of *añ* (mouth and nose). 3. Tracing of *sindaux* (mouth). 4. Tracing of *yōōxai* (mouth). 5. Palatogram of Hupa *d*. 6. Palatogram of English *d*.

To register the exact time of the beginning, culmination, and end of tongue movements, the Rousselot apparatus may be employed.[1] This apparatus (figure 23) consists of a kymograph — a cylinder horizontally placed, driven at a uniform rate of speed by delicate clockwork. A sheet of paper is placed around the cylinder and given a thin, even coating of smoke. The fine elastic tracing point of the Marey tambour resting upon this paper registers the varying force of the column of air which issues from the mouth or nose, or any compression of a closed chamber that may be connected with it. For registering the movements of the tongue, a rubber bulb is placed between the tongue and the roof of the mouth at the desired point. This bulb is connected with a Marey tambour by means of a rubber tube which passes out through the side of the mouth-piece into which the words are spoken. Two tambours are used, one connected with the bulb and one with the mouth-piece, arranged so that their tracing points will make but a single line when the carriage with the tambours is pushed along while the

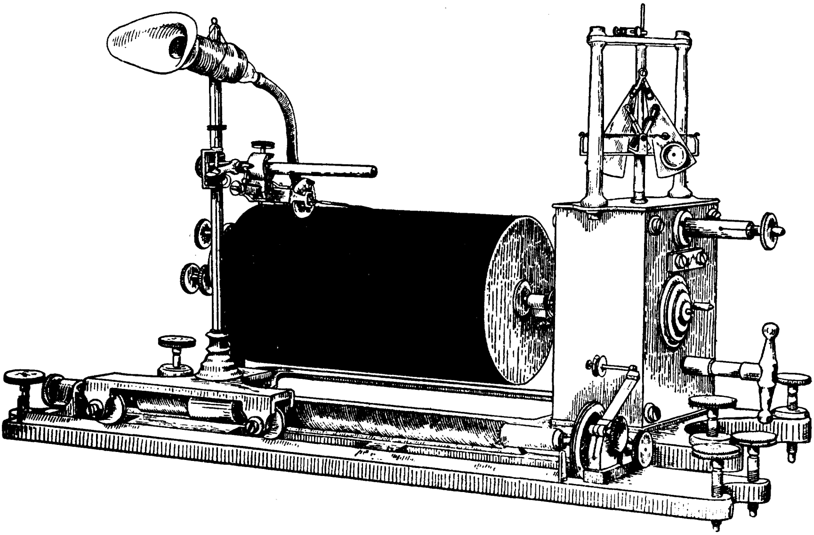

FIG. 23. — Kymograph of the Rousselot apparatus

cylinder is at rest. When the word or phrase is spoken two synchronous tracings are made (pl. XXXVI, fig. 1). In this case the upper one is from the mouth-piece and shows the varying force of the air column from the oral passage, the lower one is from a bulb placed on the point of the tongue, the elevations in the tracing indicating the time of the raising of the tongue and consequent pressure upon the bulb. These correspond to the moments of closure of the oral passage for *t*, *n*, and *n* in the Hupa word *tanan*, 'water.'

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[1] Many parts of this apparatus have been designed and the methods of its use perfected by Abbé Rousselot of Paris. Rousselot, *Principes de phonétique expérimentale*, Paris, 1897.

The movements of the back portion of the tongue and the exact points of its contact with the soft palate are difficult to observe directly, and mechanical aids are not easily employed. This is greatly to be regretted because several of the American languages have whole series of sounds formed well back in the mouth.

The movements of the velum may sometimes be directly observed. The uncertainty concerning one Hupa sound was removed in this manner. The subject was made to open his mouth widely, facing a strong light. When he uttered the sound in doubt, the velum was seen forced outward and strongly vibrating in the current of expired air. The position of the velum may be inferred from tracings made with the Rousselot apparatus. A bulb of glass open at both ends is inserted in one of the nostrils with a rubber tube connecting one of its ends with a Marey tambour. By this means the flow of the air through the nose is registered and the duration of the opening of the nasal passages by the lowering of the velum is ascertained. In plate XXXVI, fig. 2, tracings of the Hupa word *añ* (*ang*), 'yes,' is shown. The lower tracing is from the nose, showing considerable nasalization of the vowel and a decided nasal sound after the vowel is terminated by the closing of the oral passage.

The movements of the walls of the mouth and throat, and the condition of the tongue as to shape and rigidity are exceedingly difficult to determine or to record. On these largely depend the quality of the vowel sounds.

The action of the glottis, both as to the degree and time of sonancy may also be shown by Rousselot tracings. These may be made with the mouth-piece, when the vibrations of the vocal chords will appear, if the tambour is properly adjusted, as tiny waves imposed upon the breath curves. For more exact work a thin membrane of rubber may be applied to the wall of the larynx and the vibrations conveyed to a tambour by means of compressed air. It is possible in this manner to settle the puzzling questions in American languages concerning the degree and constancy of sonancy in certain consonants.

So far only the physiological causes of the sounds have been considered, and they are the most important, since if one understands the cause he can with practice produce the result. There is however another side to phonetics — the physical. Puffs of air of certain regularity of occurrence, force, and shape fall upon the ear and produce the sensation known as sound. Here, in the realm of physics, exact measurements are possible and well known laws prevail. It is quite possible to make visual records of the sounds of a language, to analyze and measure them, and to tabulate the results. Comparisons may then be made within the bounds of the language itself, or between it and other languages, and its physical characteristics made a matter of permanent record.

For making tracings of the consonants, a mouth-piece connected with a Marey tambour is employed. The stopped consonants appear with horizontal straight lines of no elevation for the period of silence caused by the closure of the mouth passage which change almost instantly into vertical lines when the explosion occurs. The continuant consonants are represented by lines which gradually rise and fall as the air issues with greater or less force. If these continuants are also fricatives, irregularities appear in the lines, due to interference with the air column as it passes the constrictions of the mouth passage. Plate XXXVI, fig. 1, shows the aspirated *t*, and the middle of figure 3 of the plate, *d* as spoken in the Hupa language. The initial sound in the tracing last referred to is *s*, showing a gradual smooth curve, and figure 4 of the plate shows coarse, irregular waves produced by the vibration of the velum in the Hupa sound mentioned on page 616.

The vowel sounds, which are the most difficult to deal with from the physiological side because of the difficulty in ascertaining, or making a record, of the shape and rigidity of the mouth and throat chambers in which the vowels resound, are in theory easily disposed of from the physical side. Theoretically the vowel is a harmonic series consisting of a fundamental and at least two overtones. The individual waves making up a vowel need to be traced, enlarged, analyzed, and the results expressed in terms of the coëfficients of their fundamental and partial tones. These results may then be compared with the results obtained from an analysis of the other vowels of the same language, or of similar vowels of other languages. The difficulty in practice consists in eliminating, or allowing for, certain constant errors due to the resonance of the chamber of the speaking tube and the natural period of vibration of the diaphragm which must be employed in recording the sounds.

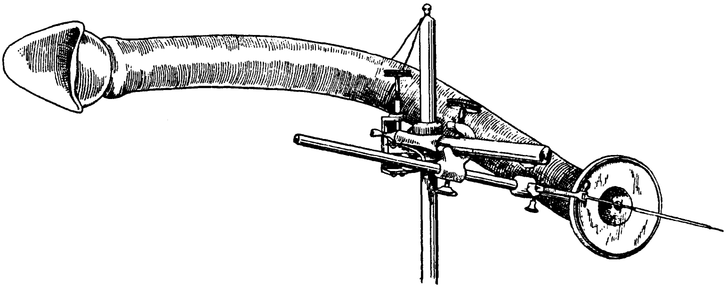

FIG. 24. — Vowel tracer

Hermann[1] and Bevier[2] have made tracings from the wax cylinders of the phonograph. The former transferred them to smoked paper, enlarging them by means of a system of levers. The latter successfully employed a mirror and a beam of light for the same purpose. Scripture made use of the flat disks of the gramophone and a system of levers.[3] The method employed at the University of California is to make Rousselot tracings direct from the voice and to enlarge them by microphotography. A rather large and long rubber speaking tube is employed with a glass diaphragm 2 inches in diameter and .008 of an inch thick (figure 24). The glass disk is connected at its center with a steel swing-needle which carries a straw with an attached tracing point of horn. The surface of the cylinder upon which the tracing is made travels at the rate of 28 centimeters (11 1/8 inches) per second. The waves so obtained are analyzed by means of the Le Conte curve analyzer[1] after they have been sufficiently enlarged.

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[1] Hermann, *Phonophotographische Untersuchungen, I.*, Arch. f. d. Ges. Physiol., 1889.

[2] Bevier, *The Acoustic Analysis of the Vowels from the Phonograph Record*, Physical Review, vol. X, 193 (1900); vol. XIV, 171 (1902).

[3] Scripture, *Researches in Experimental Phonetics*, Stud. Yale Psychological Laboratory, 1899.

The purely physical effects of language, the sounds themselves, may be recorded and preserved upon the commercial phonographs, which employ wax cylinders. There is difficulty in breaking up the sounds of a strange language so recorded into words and in connecting these words with their proper meanings. This difficulty may, in part, be overcome by means of carefully prepared texts with interlinear translations to accompany each cylinder. It is greatly to be regretted that phonograph cylinders are not more durable and permanent. Phonograph records, in any case, can never be sufficient in themselves because they utterly fail to show the physiological processes by which the sounds upon them have been produced, and after all the manner of making the sound is more important in the study of language than the sound itself.

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[1] Le Conte, *An Harmonic Analyzer*, Physical Review, vol. VII, p. 27 (1898).